



Research papers

Enhancing flash flood risk perception and awareness of mitigation actions through risk communication: A pre-post survey design

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ABSTRACT

Flood risk management is gradually shifting from a risk-based approach to an integrated one that, among other elements, considers risk communication (RC) as a means of boosting resilience. Regardless of the above, few scientists have tackled up to now the integration of RC into flood risk management. In this connection, this particular study seeks to check out the potential of a risk dialogue approach (based on an ad hoc RC strategy) to change attitudes and behaviours in relation to flash flood risk. Via a pre-post survey design, we evaluated risk perception and awareness regarding a Civil Protection Plan (CPP) implemented locally (i.e., in the municipality of Navaluenga, central Spain). For this particular objective, a questionnaire survey was created, and 201 adults (representing more than 10% of the population census) were interviewed twice in a one-year period. Before the second survey, an RC strategy was created. The RC strategy comprised briefings, quiz answers, storytelling, a contest of videos and photographs about past floods, and an intergenerational workshop. A *t*-test for paired sample analyses and a general linear model (GLM) repeated measures ANOVA were applied to identify changes in risk perception and awareness. Our results indicate that the RC strategy did increase flood risk perception in Navaluenga in the long term (lifetime). Also, it increased the level of awareness of the various features that comprise the CPP, enabling people to be more competent in facing a flash flood. Some cognitive biases detected in the perceptual process of human beings may shed some light on the results obtained. The implementation of well-thought-out RC strategies can play a role in improving resilience, particularly in geographic areas such as the Iberian Peninsula, in which climate change scenarios indicate a likely increase in the severity and frequency of flooding.

1. Introduction

Mountainous river basins with a drainage area of up to a few hundred square kilometres quite often respond quickly to heavy precipitation events and/or the orographic control of the spatial distribution of rainfall intensity (Gaume and Borga, 2008; Lombroso and Gaume, 2012). This hydrological response is mainly due to the topographic relief, the steepness of slopes and, consequently, the strong hydrological connectivity that characterizes these basins (Bodoque et al., 2015). Additional physical attributes, like soil types, land uses and impervious area, together with the degree of soil saturation before the flash flood occurs, will additionally condition the flash flood potential of extreme precipitation events (Hapuarachchi et al., 2011; Ballesteros-Cánovas et al., 2015). The ensuing floods have a fast hydrological response, recognized by hydrographs showing steep rising

and falling limbs and, accordingly, short lag times. The above results in what are known as “flash floods” due to their rapid onset, i.e., with only a few hours between rain falling and flooding (Borga et al., 2007; Marchi et al., 2010; Naulin et al., 2013; Gourley et al., 2017) and, therefore, the short warning times that lead to the majority of flood deaths worldwide (Barredo, 2007). Therefore, the primary challenge in risk management is related to the short time available for lessening the risk, which requires preparedness and response actions to be put into practice (Bodoque et al., 2016a).

The approval of the EU Floods Directive (Directive 2007/60/EC) has meant a change concerning how studies on risk mitigation should be addressed (Hall et al., 2003; Serra-Llobet et al., 2013). In this respect, until 2007 fragmented approaches to the problem were developed. They were mainly based on partial analysis of the hazard, as usually only the flooded area was considered (Hooijer et al., 2004). Also, risk

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mitigation was primarily based on the design of structural measures (e.g., levees, reservoirs for flood attenuation), or to a lesser extent on non-structural measures (e.g., civil protection plans (CPPs), land use planning) (Merz et al., 2010). Specifically, structural measures followed a reactive approach, so that once a catastrophic event had occurred, they were put in place to prevent flood risk (Sayers et al., 2002). Decision-makers have mistakenly perceived these measures as instruments to increase safety levels which has facilitated the development of different types of land uses in the flood plain, thereby increasing flood risk i.e., levee effect or safe development paradox (Tobin, 1995). The effectiveness of this total protection approach has been questioned lately since, despite the significant investments made during recent decades, the growth in flood damages has followed a clear positive trend (Bradford et al., 2012). The above could be either as a result of flood events with a magnitude not considered during the design of structural measures, or due to their poor design as uncertainty was not considered, or it was characterized inadequately (Vis et al., 2003).

Since 2007 the application of the EU Floods Directive has involved the adoption of comprehensive risk management schemes, which have been based on the premise that zero risk situations do not exist (Kubal et al., 2009). Therefore, the ultimate goal of the measures to be applied should be partial mitigation of risk, and they must be designed to diversify and adapt different risk reduction strategies. This approach requires that the actions to be developed must be continuously evaluated. To this end, they must be adequate in terms of both the territory and its social context, which is a critical aspect as risk management based simply on a technocratic approach may give people a false sense of security (Lawrence et al., 2013). The foregoing is because the social dimension of flooding mainly related to the subjective aspects of risk (i.e., emotional feelings, such as the fear, worry or trust that individuals have concerning flood risk), which determines people's risk perception, is usually not integrated into the risk management process (Birkholz et al., 2014). Within this context, social resilience, i.e., the ability of groups or communities to cope with external stresses and disruptions (Adger, 2000), provides a practical framework for addressing integrated risk management schemes. Thus, the characterization of social resilience enables flood preparedness and response to be improved as it facilitates the correct implementation of mitigation actions to reduce the negative consequences of flash flooding (Bodoque et al., 2016a). Lately, the concept of resilience has gained importance thanks to the impulse provided by the Hyogo Framework for Action (in force until 2015) and the Sendai Framework for Disaster Risk Reduction (to be developed during the period 2015–2030) in which resilience is one of the global targets (Thieken et al., 2016; Horn and Elagib, 2018).

The analysis of risk perception, together with the design and implementation of RC strategies, are critical stages in flood risk management since they facilitate the establishment of a response to flood warnings and initiatives to boost community preparedness (Bubeck et al., 2012; de Boer et al., 2015; Fox-Rogers et al., 2016; Morss et al., 2016). Understanding the characteristics of local communities constitutes a priority to enhance social resilience. So, the extent to which a community can show resilience after a flood largely depends on risk perception, which is related to the social context in which a given flood event occurs (Wickes et al., 2015). In addition, risk perception depends on different psychological variables, including intuitive evaluation of risk and qualitative reflections such as fear and trust in decision-makers (Figueiredo et al., 2009). Therefore, knowing how people perceive flood risk is crucial in regard to fixing what aspects related to the flood risk management process should be disseminated to enhance flood preparedness and, therefore, to increase social resilience by ensuring that appropriate and effective measures for flood risk mitigation are taken (Bradford et al., 2012). Nevertheless, both risk perception and RC are often neglected when developing flood risk management, which means that management strategies have often failed, as scientists and technicians can perceive flood risk in a very different way to how the public perceives it. The first studies on risk perception go back to the

1940s (White, 1945). Most of the research conducted on this topic so far has been of an exploratory nature. However, the theoretical frame developed in the field of social sciences, i.e., psychometric paradigm (Slovic, 1992) and heuristic approaches (Kahneman and Tversky, 1996), has usually been neglected (Kellens et al., 2013).

The effectiveness of RC in improving community preparedness and awareness as part of effective flood risk management plans has scarcely been studied. Previous work has mainly focused on conceptual approaches. So, data from RC strategies were either used to understand population perspectives on flood risks and mitigation (Haer et al., 2016; Lazrus et al., 2016) or focused on the distinction between prevention and promotion (de Boer et al., 2015). Under this general approach, the effectiveness of two-way and one-way RC strategies to improve preparedness has also been assessed (Maidl and Buchecker, 2015). Other research focused on determining how useful flood hazard maps (as RC tools) are regarding disaster prevention awareness (Mizuki, 2012), or exploring how local managers use flood hazard maps for RC purposes (Kjellgren, 2013). In addition, identification of RC gaps and the creation of strategies to enhance information sharing have also been addressed (Stewart and Rashid, 2011).

Accordingly, the primary objective of the present study is to assess the degree to which RC enables risk perception to be improved at the local level. Likewise, it intends to determine the extent to which RC enhances the level of knowledge of civil protection and emergency management strategies created with the primary objective of safeguarding people and assets from the effects of flooding. So, the research undertaken here targeted the achievement of a change in attitudes and behaviours through a risk dialogue approach (Demeritt and Nobert, 2014). To do so, an ad hoc RC strategy was designed and put into practice with the aim of creating awareness (understood as people's awareness of actions that they should – according to the CPP – take before, during and after a flash flood) of the reality of flash flood risk and the existing risk mitigation tools. The effectiveness of this RC strategy was assessed via a pre-post survey design, which consisted of two stages carried out through a questionnaire survey by trained interviewers both previously and subsequently to the implementation of the RC strategy.

2. Material and methods

2.1. Study site

Navaluenga is situated in central Spain on the banks of the Alberche River and the Chorrerón Stream (Fig. 1). According to the census of the Spanish Statistical Office, Navaluenga has a population of 1,902 locals (data for 2017). Navaluenga has suffered flash flood events related to the Alberche River and the Chorrerón Stream since at least the late Middle Ages, as attested by existing historical documents (i.e., obtained from municipal and ecclesiastical archives). The latest events in the 1990s and at the beginning of the 2000s caused considerable economic losses and placed part of the local population at risk (Bodoque et al., 2016a).

Since Navaluenga has a medieval origin, with a compact urban structure made up of irregular closed-street blocks, two-storey buildings are predominant, and over 50% of individuals reside within the flooding zone. It is worth highlighting that the dependency ratio (i.e., a measure indicating the number of dependents, aged zero to 14 and more than 65 years old, to the entire population, aged 15 to 64) reaches 60%. Usually, the population of Navaluenga expands substantially during the summer season when it gets to around 20,000 inhabitants. Thus, the exposed population could multiply tenfold during the summer and could double or even quintuple during holidays and at weekends (between 5,000 and 10,000 inhabitants).

The information source and strategy for building the CPP against flood risk in Navaluenga were based on the Spanish legislation on this particular matter (Spanish Ministry of Justice, 2010). A far more

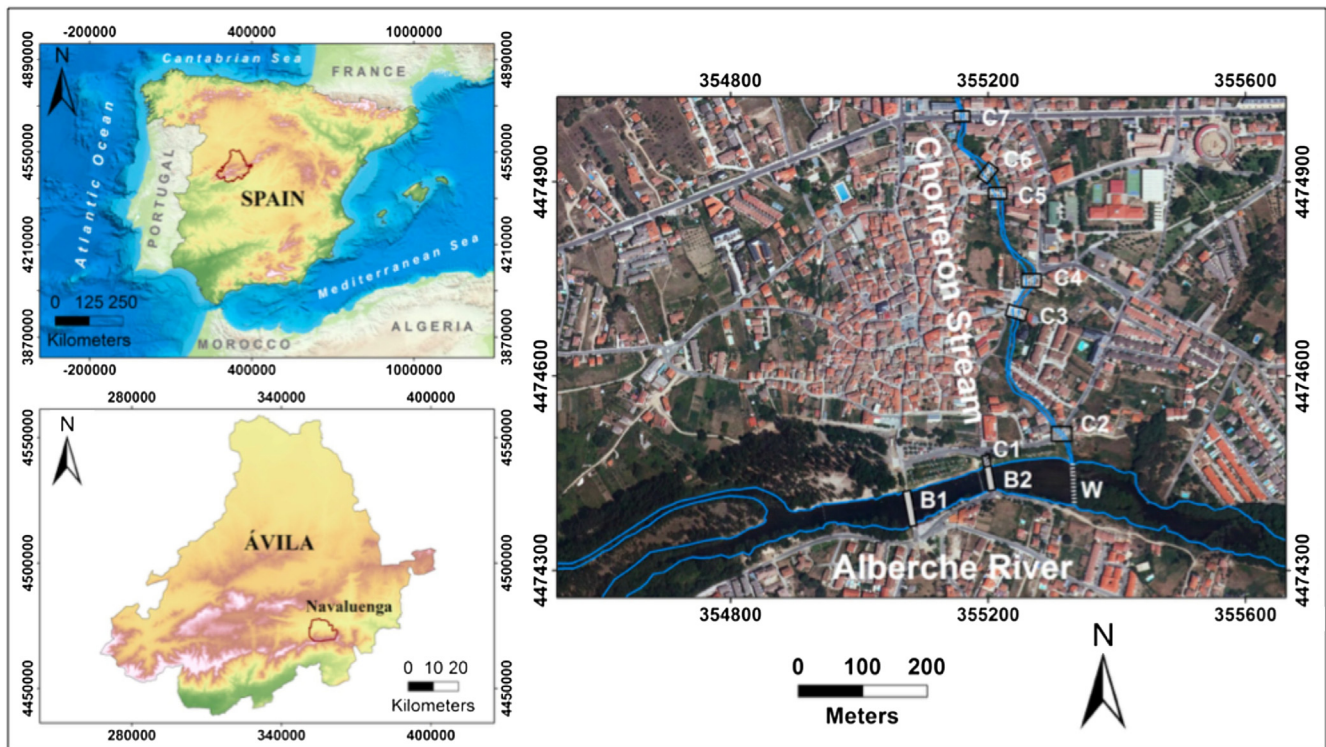


Fig. 1. Location of the study area. Coordinate system: ETRS89, UTM Zone 30 N. There are several points of conflict in the reaches studied: (i) B1 and B2 correspond to bridges on the Alberche River; (ii) W is a weir also on the Alberche River; and (iii) C1 to C7 represent culverts on the Alberche River and the Chorreron Stream. These hydraulic structures increase the hazard if a flood occurs.

detailed explanation of the CPP of Navaluenga can be read in Bodoque et al. (2016a).

2.2. Design of the RC strategy and procedures

With the intention of improving the understanding of flood risk, including local people's degree of awareness, an RC strategy was designed for the general public. Thus, different actions were taken, such as the disclosure of detailed flood maps, informative talks, a contest of questions and answers, storytelling, a contest of videos and photographs about past floods and an intergenerational workshop on past floods. All these actions were designed from four basic premises:

- I. *In-depth knowledge of the flood hazard and risk of flooding.* There are detailed flood maps, i.e., with a representation scale of 1:5,000 or 2x2 m spatial resolution (Fig. 2), published for more than two decades from the early 1990s to the present day. So, mapping of flood-prone areas is available for different return periods (i.e., 50, 100 and 500 years), in the form of a poster exhibited in the town hall building (since 1996). Flood hazard maps published in several book chapters and papers in scientific/technical journals are also available in the municipal library (from 1996 to 2001). New flood hazard and flood risk maps, including cost-benefit analysis of mitigation measures, i.e., from 2008 to 2016 (Ballesteros-Cánovas et al., 2013; Bodoque et al., 2016b), have also been produced. In addition, since 2014, flood hazard and risk maps have been available on the Internet, such as those included in the National System of Floodable Areas Cartography (MAPAMA, 2014) that meet the EU Flood Directive requirements for procedures, contents and design.
- II. *Knowledge of the local social and associative reality* of Navaluenga, detecting the primary social agents that can disseminate and streamline the plan (known as interested parties, groups and organizations) (Trettin and Musham, 2000). For this purpose, an attempt was made to involve the Town Council and the security

forces, but also cultural associations (e.g., youth, homemakers, retirees) and the committee for protection and rescue at the local level. For this, the figure of an activity coordinator, born in the locality and well known by everyone, was essential to involve a broad enough sector of the population of Navaluenga. In this regard, Martens et al. (2009) highlighted the role of the diversity of the people, which determines that RC has to be adapted based on how different groups of individuals perceive risk.

- III. *A detailed analysis of the results obtained in previous studies with the target population*, identifying community groups (clusters) who needed improvement in their knowledge of the CPP, and their socio-demographic profiles (see details in Bodoque et al., 2016a), for example a large population sector with a lack of knowledge of the CPP (group or cluster 2; see details in Bodoque et al. (2016a)). Its key features are: permanent residents (75%); mostly women (63%); aged 35–54 (51%); school age (high school, 46%); and access to the Internet. This approach is in line with the proposals of Renn (Renn, 2005), which underscored the value of adapting risk communication to the concrete needs of the people, and Basic (2009), underlining the public's risk perception as a key factor in building effective RC strategies.
- IV. *A careful bibliographic review of the approaches followed by different RC strategies*, with the intention of finding original and innovative activities that were potentially applicable. To this end, we examined the compilations of experiences, such as those collected in Kellens et al. (2013) and Morss et al. (2016).

RC covers a broad scope of exercises, such as encouraging interest in environmental issues, increasing public awareness, influencing people's attitudes and behaviour, acting in emergency situations, aiding in decision-making and assisting in conflict resolution (Boholm, 2008). Based on this approach and the integration of the four basic premises previously stated, the design of the RC strategy was based on five actions aimed at a specific target audience and using attractive and

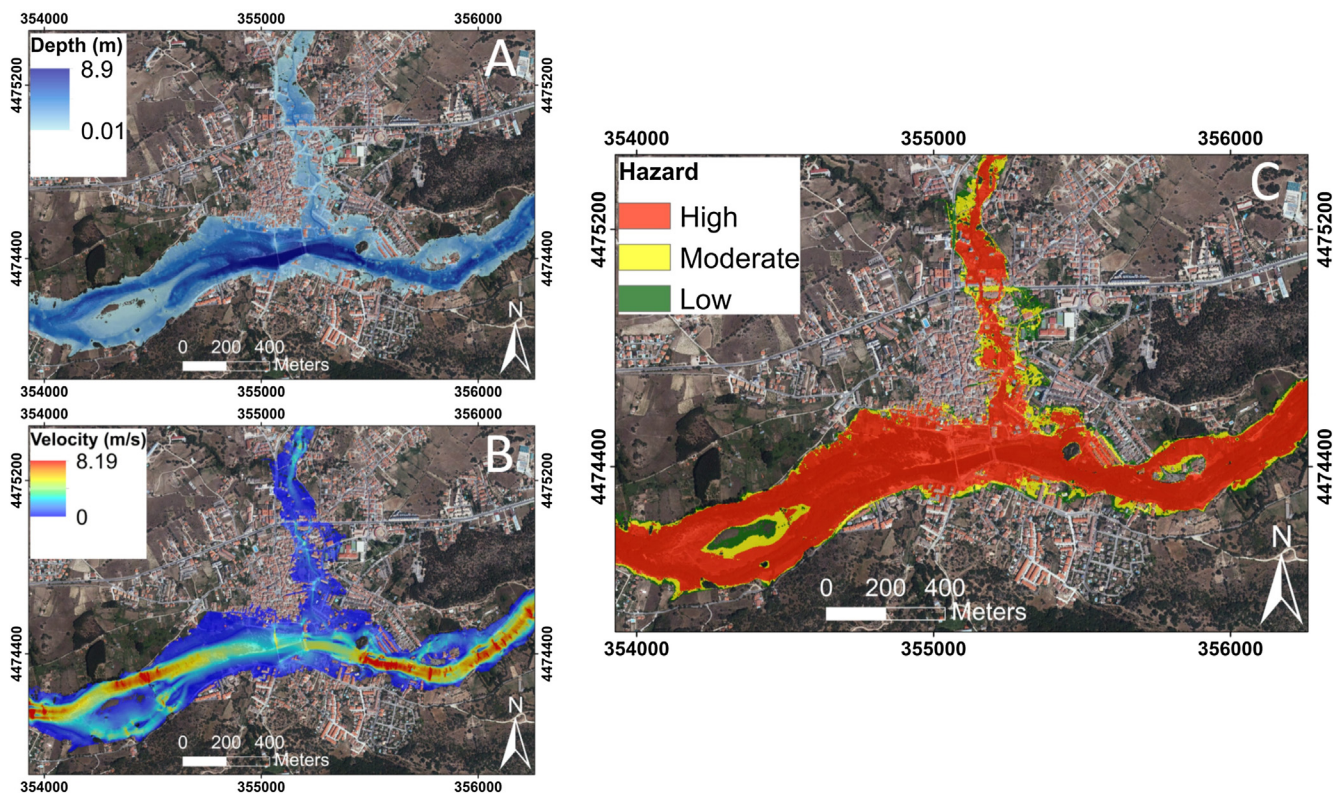


Fig. 2. Hazard map of Navaluenga obtained by multiplying and subsequent reclassification of grids of water depth and flow velocity corresponding to the 100-year flood. These maps were obtained by implementing a two-dimensional hydrodynamic model. It was based on a rectangular-triangulated irregular network obtained from the digital surface model (DSM) available for the study site. This DSM was derived from raw LiDAR data points with a density of 0.5 points·m⁻² and an altimetric accurateness of 20 cm. Roughness was characterized from official land use mapping on a scale of 1:25.000. For this purpose, the appropriate values of Manning's *n* were assigned to every land use unit (see Bodoque et al., 2016a,b for a detailed description).

Table 1
Design of the RC strategy, including the actions, the target audience and the expected results.

Actions	Target audience	Communication tool	Expected results
Disclose maps of flood hazard and flood risk	The whole population, including urban developers and technicians	Exposed poster in the town hall, publishing of book chapters and journal papers, uploading the flood maps to the Internet	Generalized improving of perception concerning the real flood risk situation
Informative talk	The whole population,	Oral presentation with slides	Generalized knowledge of the existence of the plan
Contest of questions-answers	Youth of school-going age (secondary education), with parents of cluster 2**	Municipal website Informational posters Email	Transfer of population from cluster 2** to cluster 3*** of risk perception
Storytelling and photographs/ videotapes competitions	Adult and elderly population of cluster 1*	Municipal website Informational posters	Transfer of population from cluster 1 to cluster 2 of risk perception
Intergenerational workshop on past floods	Children and youth population	Participatory face-to-face exchange of experiences	Increased risk perception among the child population, not surveyed and never experienced a flood.

Notes: (see details in Bodoque et al., 2016a): *Cluster 1 = low-risk perception and low awareness; **Cluster 2 = high-risk perception and low awareness; ***Cluster 3 = high long-term risk perception and high awareness.

original tools (Table 1).
A pre-post survey design was adopted to test the impact of the RC strategy on risk perception and awareness. It consisted of two stages carried out through a questionnaire survey. The results of the first phase (February 2015) showed that both risk perception and level of awareness were low in the majority of the sample (Bodoque et al., 2016a). The RC strategy was applied in November 2015, and one month later the second stage was conducted (December 2015–January 2016).

2.3. Participants

In the second phase, information was collected from 201 out of a total of 254 adults who participated in the first phase (Bodoque et al.,

2016a). Participants in the first survey were selected using a quota sampling procedure (Robinson, 2014), in which age and gender were used as control variables. In the second survey, the same individuals who participated in the first round were contacted. For this, the last two numbers and the letter of their national identity document were used as location criteria. In this second phase, conducted after the implementation of the RC strategy, 79.1% of those who collaborated in the first survey participated. This percentage is considered sufficient to establish comparisons between the two surveys (1 and 2). Table 2 summarizes the main socio-demographic characteristics of the people surveyed after implementing the RC strategy.

A variable was generated to determine the degree of participation in the different activities designed related to the RC strategy. It was based

Table 2
Sample socio-demographic profile (N = 201).

Variables		%
Gender	Male	45.3
	Female	54.7
Age	18–34 years old	18.9
	35–54 years old	44.8
	> 55 years old	36.3
Level of studies	Elementary Education	51.7
	Secondary Education	28.9
	Higher Education	19.4
Family situation	Living alone or with a partner	33.8
	Other	16.4
	Living with dependent people (children under 12 years old, elderly and/or disabled)	16.4
	Living with children 12 years old or over	33.3
Dwelling type	One-story	17.4
	Two-story	41.3
	Two-story with basement	20.4
	Apartment building	20.9
Type of resident	Temporary resident population	29.9
	Permanent resident population	70.1
Flood exposure	Floodable area	58.7
	Non-floodable area	41.3

on three categories showing the level of knowledge and involvement in the various RC activities: those who stated that they did not know any of the activities of the RC strategy (19.9%); those who reported having heard of some of the activities, but acknowledged that they had not participated in any (54.2%); and those who reported having attended or participated in some of the RC activities (25.9%).

2.4. Measures

A questionnaire survey was designed and conducted by trained interviewers to analyse changes in perceptions of flood risk and awareness after applying the RC strategy. The questionnaire included the same measures employed in the first survey referring to these two variables (Bodoque et al., 2016a). First, flood risk perception was assessed by adjusting a general measure consisting of four items (Bourque et al., 2012) that considered the possible risk of flooding in Navaluenga and homes themselves, both in the short term (the next five years) and the long term (lifetime). The above was measured on a five-point Likert scale, ranging from highly improbable to very likely. Second, changes in awareness were assessed by inquiring about actions to take: a) before the flood to prevent negative consequences (preparedness behaviour); b) during the flood (b.1. evacuation routes and meeting points, b.2. self-protective actions and b.3. actions to take before leaving the dwelling; and c) after the flood: actions taken in houses after flooding (See Table 3). Participants were asked whether they knew what actions to take in each situation with a closed-ended question: yes or no. If they answered yes (perceived awareness), they were asked what these were through an open-ended question. The percentages of correct responses for each category, a), b) and c), were drawn from those that coincided with the actions defined in the CPP. These percentages measured the level of real awareness and were the variables used in the data analysis.

2.5. Data analysis

The data obtained were analysed using the software IBM® SPSS® Statistics 19.0. A *t*-test for paired sample analysis was used to compare the risk perception and the level of awareness before and after the RC strategy. Next, aiming to evaluate the effect of the degree of participation on risk perception and awareness, data were analysed by implementing a general linear model (GLM) repeated measures ANOVA,

Table 3

Actions (according to the CPP) that people should take before, during and after a flash flood.

a) PREPAREDNESS BEHAVIORS (before flood occurrence)
<ul style="list-style-type: none"> ● I am informed about the level of risk ● I have a first aid box available ● I keep toxic products out of the reach of water ● I keep valuables and personal documents together in a safe place. I have a radio and torch with batteries at hand ● I make sure drainpipes and water pipes are kept clear ● I keep the outside of the house free of objects that could be washed away ● I know the location of routes and places of evacuation ● I know the location of meeting points ● I know the means to use and the tasks to be carried out by each member of the family
b) ACTIONS TAKEN DURING A POSSIBLE FLOOD
b.1) Evacuation routes and meeting points b.2) Self-protective actions and measures to take before leaving the dwelling <ul style="list-style-type: none"> ● I pay attention to the alarm signal and keep the radio or television tuned for information from the Meteorological Institute or Civil Defense ● I only use the telephone to inform the authorities, for example, by ringing 112 or the municipal services ● I disconnect all electrical equipment ● I ration provisions and be sparing with heating ● I am prepared to leave the house and go to a pre-established place if you consider the situation to be dangerous or if ordered to do so by the relevant authorities
b.3) Actions before leaving the dwelling
<ul style="list-style-type: none"> ● I gather together documentation, warm clothing, small items of value, a torch and a radio ● I disconnect the electricity, gas and water ● I do not touch electrical appliances if they are wet ● I close and lock windows and doors
c) ACTIONS TAKEN IN THE HOUSING AFTER FLOODING
<ul style="list-style-type: none"> ● I carry out a preliminary inspection to eliminate the risk of structural collapse ● I do not drink water from the tap ● I remove animals killed by the flood ● With regard to the cleaning-up process and the consumption of foodstuffs, I follow the basic rules on health and hygiene stipulated by the relevant authority ● I begin the cleaning-up process on the upper floors ● I leave in the sidewalks or roadway (without hindering the circulation) the belongings that have been rendered unusable. ● I help the rescue and cleaning teams in the task of rehabilitating the portion of public road adjacent to my house

with time (before and after) as the within-subjects factor, and level of participation as the between-subjects effect. This was aimed at determining the impact of the actions planned in the RC strategy on the variables of perceived risk and awareness. Mauchly's test was applied to check the assumption of sphericity. Level of involvement was categorized into three groups, specifically: i) those who participate in one or more activities; ii) those who do not attend but have heard of the RC strategy; and iii) those who have not heard of the RC strategy as the between-subjects factor. Pairwise comparisons were made using the Bonferroni post hoc test. Cohen's proposed commonly used guidelines were used for ranking the effect size (small, partial $\eta^2 = .01$; moderate, partial $\eta^2 = .06$; large, partial $\eta^2 = .14$). Statistical significance was set at $p < .05$ (Cohen, 1988).

3. Results

3.1. Analysis of changes in risk perception and awareness

3.1.1. Changes in flood risk perception

Table 4 shows the results of the *t*-test for paired samples in the case of the variables used to measure the flood risk perception. The results only showed statistically significant differences in the perception of risk in Navaluenga in the long term ($t_{(200)} = -4.61, p < .001, \eta^2 = .096$). This perception was greater after the implementation of the RC strategy ($M = 3.38; SD = 1.3$) than with the one obtained before conducting the said strategy ($M = 2.91; SD = 1.27$). In the short term (next five years), there were no statistically significant differences in the perception of risk in Navaluenga. When the focus is placed on the houses of survey

Table 4
Mean differences in flood risk perception before (1) and after (2) the implementation of the RC strategy.

Variable	M (SD) (1)	M (SD) (2)	T (200)	p	η^2
Navaluenga in the next 5 years	2.15 (1.05)	2.08 (1.04)	.756	.450	.003
Navaluenga in your lifetime	2.91 (1.27)	3.38 (1.30)	−4.608	< .001	.096
Your home in the next 5 years	1.40 (0.81)	1.40 (0.83)	.079	.937	.000
Your home in your lifetime	1.72 (1.09)	1.75 (1.09)	−.432	.666	.001

Note: 1 = First survey period; 2 = Second survey period.

participants, no statistically significant differences are observed either in the short term or in the long term (lifetime).

When the analysis was carried out between the two surveys but controlling for the effect of the degree of participation of the people interviewed in the activities designed in the RC strategy, similar results were observed. The GLM repeated measures ANOVA revealed that there were significant statistical differences in the perception of risk in Navaluenga in the long term ($F(2,198) = 16.80$; $p < .001$; partial $\eta^2 = .078$), although these differences only occurred among two of the three groups considered. So, post hoc Bonferroni revealed statistically significant differences between the two survey periods in the case of participants who did not know anything about the RC strategy and participants who were not involved in the RC strategy though they knew of it. By contrast, the increase in the perception of risk in Navaluenga throughout life was not statistically significant in the case of those subjects who had a higher level of participation in the RC strategy activities. Fig. 3 graphically reproduces these results. Data relating to the descriptive statistics of this analysis and the contrast of means by post hoc Bonferroni test can be seen in Table 5.

3.1.2. Changes in awareness

As regards the level of awareness concerning the actions planned in the CPP before, during and after a flood (Bodoque et al., 2016a), the results showed the high incidence of the RC strategy, as significant statistical differences were found in the level of awareness of these actions. As a result, it was concluded that there was a greater knowledge of the CPP in the second survey than in the first one. Table 6 shows the results of the *t*-test for paired samples.

In relation to the five categories of awareness regarding the CPP (i.e., avoidance of negative consequences; evacuation routes and meeting point; self-protection behaviours; actions before leaving the home; and actions after leaving the home) (Bodoque et al., 2016a), and taking into consideration the levels of participation, the results of the GLM repeated measures ANOVA showed the existence of statistically significant differences between the two survey periods. In this regard, post hoc tests using Bonferroni correction showed a statistically

significant increase in awareness, except among those who had not heard of the RC strategy. After conducting the RC strategy, those who had a higher level of participation in the different activities of the RC strategy showed the most considerable improvement in the five categories of awareness. Fig. 4 graphically reproduces the results explained above. Data related to the descriptive statistics of this analysis and the contrasts of means by post hoc Bonferroni test are exhibited in Table 7.

3.1.3. Effectiveness of each action of the RC strategy

In relation to the influence of actions on the variables of perceived risk and awareness, Table 8 shows that only three of them had a significant impact. Specifically, informative talks focus, among other factors, on flood hazard and detailed risk maps allowed the knowledge of evacuation routes and meeting points to be increased ($F(3,188) = 4.74$; $p < .01$; partial $\eta^2 = .070$). The intergenerational workshop on past floods increased the knowledge of evacuation routes and meeting points ($F(3,188) = 2.90$; $p < .05$; partial $\eta^2 = .044$) as well as actions before leaving the home ($F(3,188) = 2.84$; $p < .05$; partial $\eta^2 = .045$). Finally, the contest of questions and answers was the most effective action since it improved the knowledge on three of the five categories considered, i.e., avoidance of negative consequences ($F(3,188) = 4.97$; $p < .01$; partial $\eta^2 = .074$), self-protection ($F(3,188) = 5.43$; $p < .01$; partial $\eta^2 = .080$) and actions after leaving the home ($F(3,188) = 4.52$; $p < .01$; partial $\eta^2 = .067$). For these significant effects, the changes in the level of awareness between the two surveys are shown in Fig. 5.

4. Discussion

4.1. Comparison with other studies and critical assessment

The results of this study were based on a risk dialogue approach developed through a pre-post survey design, which consisted of two stages supported by a questionnaire designed ad hoc. They were filled out by a statistically significant portion of the census population of the municipality of Navaluenga (central Spain), both before and after the RC strategy was implemented. The results obtained make it possible to argue that risk communication, based on the active participation of communicators and receivers, might have a positive impact in improving social resilience, as it helps to develop the local capacity to understand and take the lead (Pain, 2004). So, two of the activities undertaken in the RC strategy (i.e., the intergenerational workshop on past flash floods and the contest of questions and answers), which involved the active participation of receivers, had a positive impact on the variables of perceived risk and awareness. This shows the importance of incorporating people at the core of RC as a means for raising awareness via co-producing along with experts shared knowledge and outputs (Mees et al., 2016). The foregoing is in line with the findings of previous research (Whitman et al., 2015; Rollason et al., 2018).

Notwithstanding the above, it should be pointed out that because this research is not a laboratory experiment, causal inferences from the obtained results must be taken with caution. Although some important variables, such as flood events, were deemed irrelevant during the two stages of data collection (flood events never happened during either of them), there are many other variables that could have escaped research control. Future similar studies should be carried out to establish causal

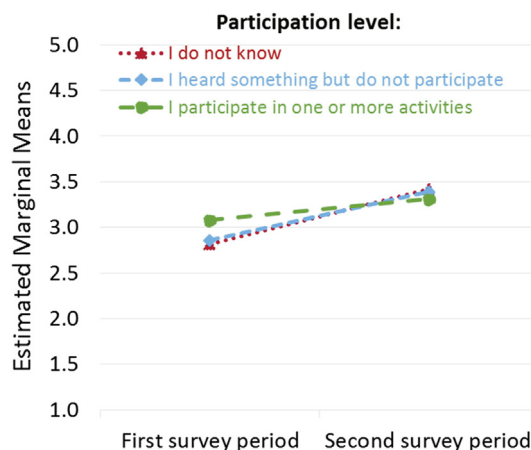


Fig. 3. Lifetime risk perception differences depending on the level of participation in the RC strategy.

Table 5

Differences in lifetime risk perception in Navaluenga, depending on the level of participation in the RC strategy.

Participation Level	M (1)	M (2)	Mean differences. (1–2)	N
I do not know	2.82	3.42	–.60*	40
I heard something but do not participate	2.86	3.39	–.53*	109
I participate in one or more activities	3.08	3.31	–.23	52

Note: * $p < .01$; 1 = First survey period; 2 = Second survey period.

conclusions. This study also places emphasis on the link between flood risk perception and RC. The analysis of the RC strategy designed to raise local people's awareness has proved its effectiveness, as it has been shown that the population has acquired a greater awareness of those fundamental aspects gathered in the CPP. Specifically, two relevant results support this conclusion: 1) those subjects who were unaware of the RC strategy did not increase their knowledge of the actions included in the CPP; 2) the change to a greater understanding of the CPP was associated with the degree of involvement of the participants in the RC strategy. Therefore, those who were most involved were the ones that obtained a higher percentage of hits on the activities to be carried out before, during and after a flood, included in the CPP. The statement above should be contrasted with future research involving those permanent residents who did not participate in either of the two survey processes, as well as non-permanent residents. Additionally, in future studies, a follow-up should be carried out to determine whether the communication plan designed has had a long-term effect on the residents of Navaluenga and to analyse the possible mediating effect that awareness has had on the perception of flood risk (Lima et al., 2005).

This study has shown that well-designed RC strategies are associated with an increasing public awareness of CPPs. Accordingly, CPPs may be implemented more quickly and in turn will be more efficient in minimizing the effects of floods once a given event has occurred. In fact, this study also shows that flood risk management in general, and CPPs in particular, should not be put into practice without a guarantee of the participation of the local people. This is because flood risk management based solely on a technocratic approach frequently differs significantly from the risk perception of the community, which may cause flood risk management to fail as the social dimension of flooding is not integrated into the management process (Lara et al., 2010). Our findings are in line with the studies by Terpstra et al. (2009) and Kellens et al. (2013), who concluded that RC strategies could strengthen people's risk awareness, though it has only weak effects on the public's risk perception, as well as that of Basic and Nuantawee (2004), who asserted that knowledge of the community's risk perception is a critical issue in building effective RC strategies.

As regards flood risk perception, the averages in Table 4 show that this is greater when people think of their municipality (rather than their home) and in the long term (compared to the short term), and this is true for both survey 1 and 2. This finding is in line with some of the cognitive bias research applied to risk perception. According to Uzzell (2000), people perceive an environmental hazard as being more serious the farther away it is from them; this has been labelled "environmental hyperopia". Schultz et al. (2014) also reported that the seriousness of several environmental problems was perceived as being greater at a

global level than at a local level in 22 different countries. According to these authors, this bias is based on construal level theory and the corresponding psychological distance bias (Liberman and Trope, 2008). Accordingly, the interpretation of the surrounding reality becomes more abstract (high-level construals) the farther away this reality is from the perceiver in terms of four dimensions: Geographical or Spatial (global vs local; far vs close), Temporal (future vs present), Social (similar vs different people) and Hypothetical (greater vs lower probability of occurrence). The results depicted in Table 4 are in line with those Spatial (municipality vs home) and Temporal (long vs short term) distance biases.

Focusing on the analysis of the RC strategy and its effects on flood risk perception, the results showed a non-significant increase between the two survey periods in most cases. The only statistically significant differences were detected in the perception of the risk of flooding in Navaluenga in the long term, which increases in the second survey conducted after the implementation of the RC strategy. Nevertheless, when the effect of participation is taken into account (Fig. 3), those subjects who did not participate or who had not even heard of the RC strategy were the group that increased risk perception from a statistical point of view. In other words, the only group who did not increase their perception of the risk of flooding in Navaluenga in the long term were those who participated in the RC strategy. The conclusion, then, is that the RC strategy did not increase the flood risk perception in Navaluenga in the long term.

Taking into account the finding stated some paragraphs above referring to the fact that the RC strategy increased the knowledge of the CPP, the results obtained here would support those found by Helweg-Larsen and Shepperd (2001) referring to another important cognitive bias: the optimism bias. People are more optimistic when it comes to evaluating those negative events that they believe they can control with their behaviour. When people feel competent because they know how to behave in the face of a possible negative event, this is evaluated in a more optimistic way. This could explain why people who participated in the RC strategy did not increase their level of risk perception in the long term (lifetime), unlike those who did not participate in it. The competence obtained through participation in the RC strategy could be associated with the absence of an increase in the perception of flood risk obtained in the second survey.

4.2. Policy implications

In compliance with the European Directive on flood risk management (60/2007/EC), the different river basin districts have recently completed the first water planning cycle (2009–2014). Specifically, in

Table 6

Mean differences in the level of awareness regarding the actions to take before, during and after a flash flood included in the CPP of Navaluenga (percentage of correct answers).

Variable	M (SD) (1)	M (SD) (2)	T (200)	p	η^2
Avoidance of negative consequences	4.13 (9.18)	10.15 (14.02)	–5.531	< .001	.133
Evacuation routes and meeting point	9.55 (12.50)	18.71 (15.37)	–7.446	< .001	.217
Self-protection behaviours	9.33 (15.71)	21.64 (21.61)	–7.198	< .001	.206
Actions before leaving the home	38.64 (26.97)	54.39 (26.33)	–6.447	< .001	.172
Actions after leaving the home	15.35 (12.12)	26.23 (15.24)	–8.576	< .001	.269

Note: 1 = First survey period; 2 = Second survey period.

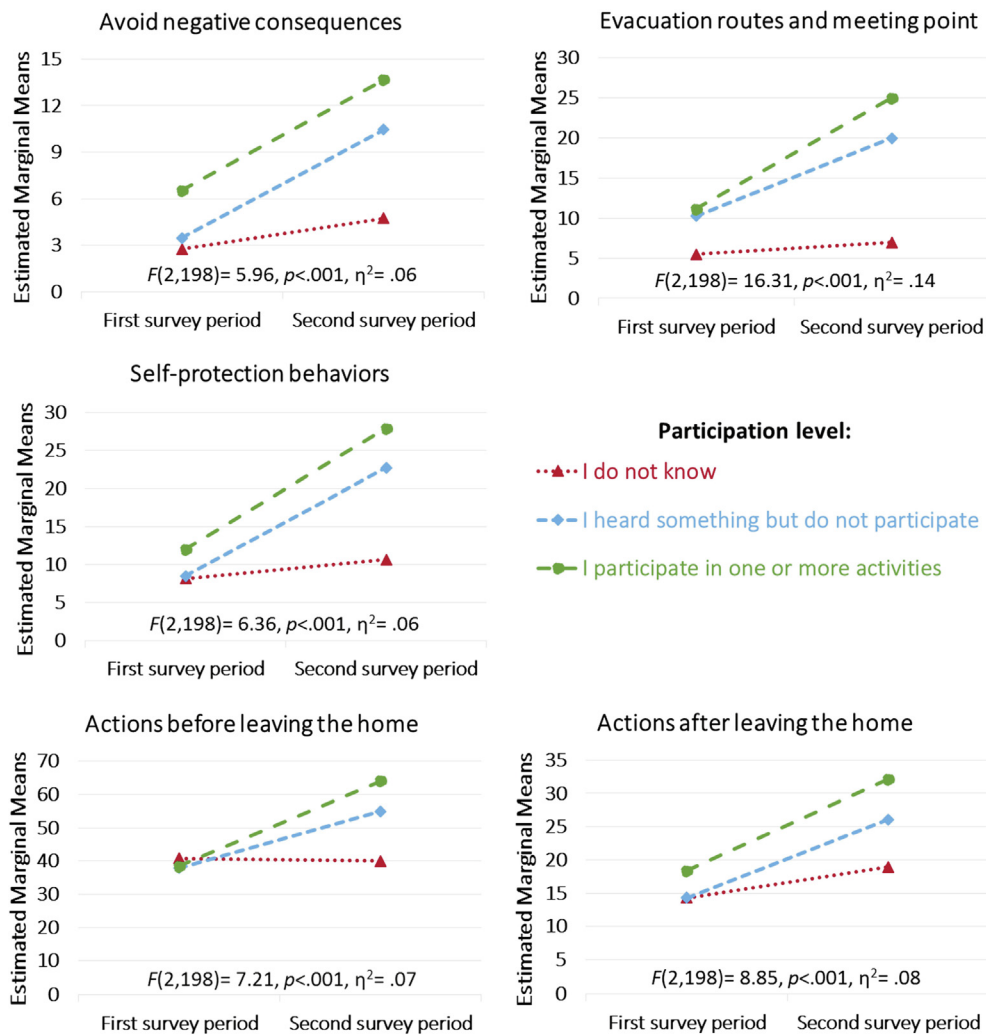


Fig. 4. Differences in the level of awareness regarding five actions included in the CPP of Navaluenga, depending on the level of participation in RC strategy. The results of the F -statistic to determine significance and effect size (partial η^2) are represented for each of the actions included in the CPP.

Table 7

Differences in the level of awareness regarding the actions included in the CPP of Navaluenga, depending on the level of participation in the RC strategy.

Awareness	Participation Level	M(1)	M(2)	Mean differences (1–2)
Avoidance of negative consequences	I do not know	2.75	4.75	–2.00
	I heard something but do not participate	3.49	10.46	–6.97*
	I participate in one or more activities	6.54	13.65	–7.12*
Evacuation routes and meeting point	I do not know	5.50	7.00	–1.50
	I heard something but do not participate	10.28	20.00	–9.72*
	I participate in one or more activities	11.15	25.00	–13.85*
Self-protection	I do not know	8.13	10.62	–2.50
	I heard something but do not participate	8.49	22.71	–14.22*
	I participate in one or more activities	12.02	27.88	–15.86*
Actions before leaving the home	I do not know	40.83	40.00	.83
	I heard something but do not participate	37.92	26.61	–9.30*
	I participate in one or more activities	38.46	64.10	–25.64*
Actions after leaving the home	I do not know	14.29	18.93	–4.64
	I heard something but do not participate	14.29	26.08	–11.79*
	I participate in one or more activities	18.41	32.14	–13.73*

Note: * $p < .01$; 1 = First survey period; 2 = Second survey period.

Spain, since transposition of the EU Flood Directive to the national legislation, flood risk management plans have been developed in which consideration of risk perception is one of the primary objectives to be addressed. A priori, the above means a significant step forward in developing sustainable flood risk management strategies, especially in Spain, where risk mitigation has been mostly based on the

implementation of structural measures (e.g., levees, dams, and so forth). They were planned to guarantee total protection of the population exposed to floods, without considering the environmental impacts of these measures, or their likely downstream effects regarding increasing flood risk (Olcina et al., 2016).

Although increasing risk perception is prioritized as one of the main

Table 8

Effects of the participation level in each activity of the RC strategy on lifetime risk perception in Navaluenga and level of awareness ($F(3,188)$ and p -value; partial η^2 is reported only for significant effects).

Variable	Informative talk	Contest of questions-answers	Storytelling and photographs/videotapes	Intergenerational workshop on past floods
<i>Risk perception</i>				
Navaluenga in your lifetime	$F = 0.40, p = .753$	$F = 1.82, p = .146$	$F = 0.16, p = .923$	$F = 1.04, p = .376$
<i>Awareness</i>				
Avoidance of negative consequences	$F = 0.75, p = .524$	$F = 4.97, p = .002$ (partial $\eta^2 = .074$)	$F = 2.45, p = .065$	$F = 0.28, p = .842$
Evacuation routes and meeting point	$F = 4.74, p = .003$ (partial $\eta^2 = .070$)	$F = 2.42, p = .067$	$F = 1.78, p = .153$	$F = 2.90, p = .036$ (partial $\eta^2 = .044$)
Self-protection behaviours	$F = 0.87, p = .456$	$F = 5.43, p = .001$ (partial $\eta^2 = .080$)	$F = 1.22, p = .304$	$F = 0.55, p = .650$
Actions before leaving the home	$F = 1.21, p = .308$	$F = 1.37, p = .253$	$F = 0.36, p = .780$	$F = 2.84, p = .039$ (partial $\eta^2 = .045$)
Actions after leaving the home	$F = 0.94, p = .422$	$F = 4.52, p = .004$ (partial $\eta^2 = .067$)	$F = 0.80, p = .493$	$F = 2.13, p = .097$

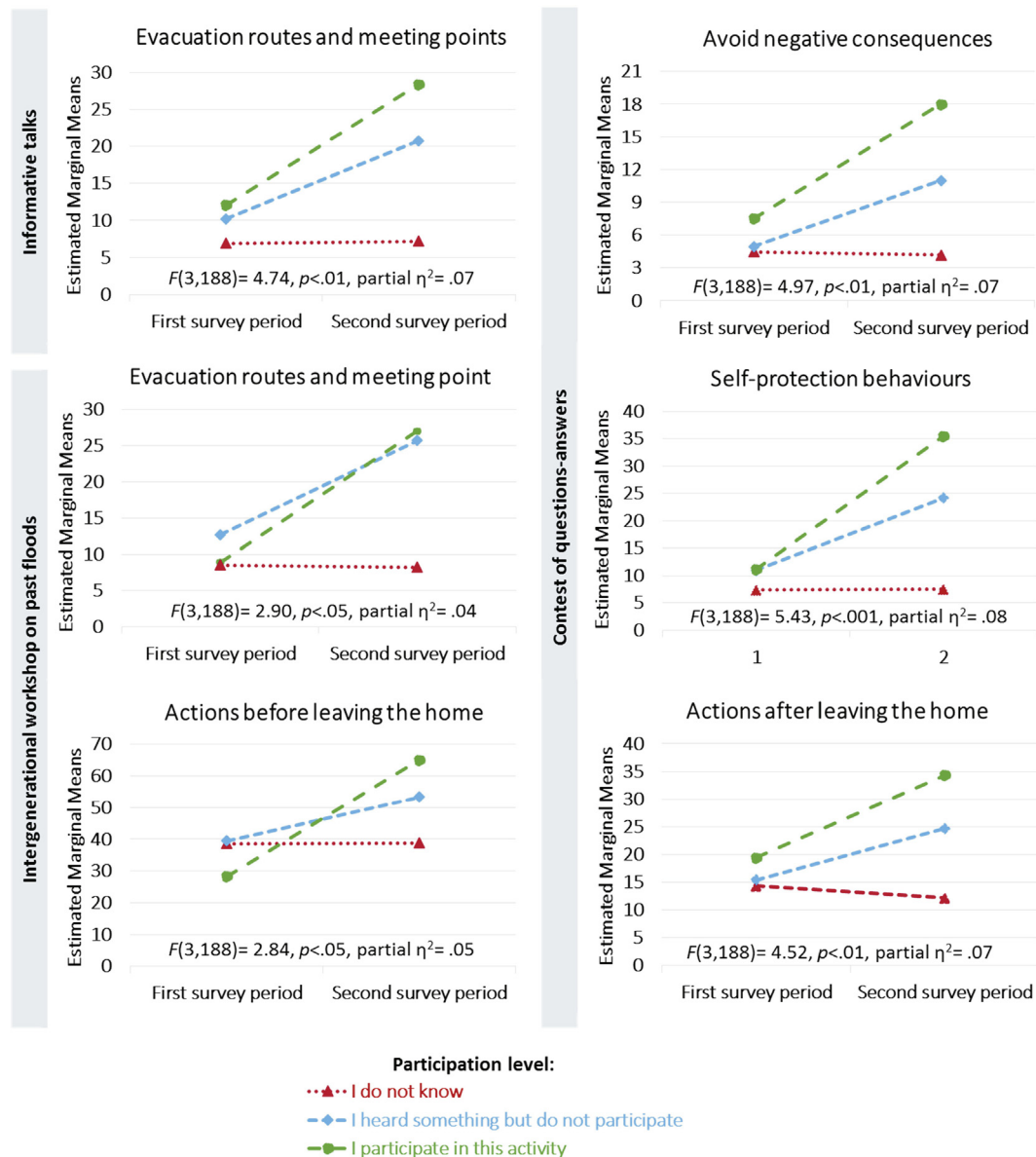


Fig. 5. Significant differences in the level of awareness for each action of the RC strategy.

objectives to be achieved in all technical documents related to decision-making for flood risk management, the fact is the above is not reflected in the implementation of specific actions with an allocated budget. By way of an example, the preliminary flood risk management plan document for the Tagus River hydrographic demarcation (CHT, 2014), in which the village of Navaluenga is included, features as a general objective: “improving public awareness with reference to flood preparedness and response, aiming to increase flood risk perception and self-protection strategies.” The document above also provides some actions to be considered in the design of risk communication strategies (e.g., informative talks or use of the Internet and media to improve awareness and flood risk perception), though no specific budget allocation is provided to implement them. Instead, it is hoped that some funds will be received from initiatives being developed by other public organisms different to hydrographic demarcations, which are developing strategies only partially related to alerts and emergency management (e.g., Spanish National Meteorological Agency). An additional limitation is that the only indicators considered for the control and follow-up of RC strategies are: i) some campaigns; ii) a number of information days; and iii) a number of administrations including information on their web pages. The shortcomings explained above have also been detected in the other hydrographic plans of the Spanish hydrographic demarcations.

Given the results obtained here, prioritizing actions focused on increasing awareness through the integration in CPPs of RC strategies is proposed, as their effectiveness and best cost-benefit ratio has been proven. It means that risk management policies should devote specific budget allocations to designing and implementing new communication strategies that are more dynamic, participatory, bidirectional (Covello et al., 1986; Steelman and McCaffrey, 2013) and focused on the citizens who have low risk perception and awareness (Renn, 2005). Particular attention should also be paid to future policies concerning the articulation of more efficient control protocols and monitoring mechanisms, such as conducting pre and post surveys (like the ones performed here). Conducting periodic surveys to check how risk perception evolves is also necessary.

As demonstrated in this study, and in line with previous research, the public participation of stakeholders involved in RC can play an important role in the improvement of awareness (Morss et al., 2016). Our outcomes reveal the importance of involving communities through the implementation of an RC strategy enabling local people to enhance their knowledge of flood risk by making this concept less abstract and more tangible, and thus contributing to improving the practical actions of individuals before, during and after a flash flood.

5. Conclusions

Improvement in risk perception and awareness at the local level has been assessed through implementing a risk dialogue approach based on an ad hoc RC strategy and a pre-post survey design. In this study, we have, for the first time, addressed a risk perception and public awareness characterization focused on improving community preparedness as an aspect to be integrated into CPP. The above is of critical importance, especially in urban areas prone to suffering flash floods. In such an event, floods have a quick hydrological response, in which flow peaks are reached within a few hours, thereby giving little or no advance warning to mitigate damage. The methodological approach deployed here enhances public awareness of flood risk and mitigation measures considered in the CPP developed at Navaluenga. Therefore, it may help people to understand the information they need to reduce the impact of flooding on themselves and their assets. RC should be generalized and consequently integrated as an essential step within flood risk management plans, which could ultimately prevent, or at least reduce, flood risk, so that more reliable management in urban areas can be put into practice as the EU Flood Directive requires.

Conflicts of interest

The authors declare that they have no conflict of interest.

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